1997 Juvenile and Adult Enumeration Studies of Coho Salmon at Black Creek, Vancouver Island

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1997 JUVENILE AND ADULT ENUMERATION STUDIES OF COHO SALMON AT BLACK CREEK, VANCOUVER ISLAND

by

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ABSTRACT

Taylor, J.A, Baillie, S.J., and Simpson, K. 2006. 1997 Juvenile and adult enumeration studies of coho salmon at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2767: *v* + 38 p.

The counting fence on Black Creek was used to enumerate the 1997 coho smolt outmigration and spawner escapement to the system. A total of 70,763 smolts were captured between 10th April and 16th June, 1997 and a further 5,829 were estimated to have migrated when the fence was inoperable. Of these, 70,395 (91.9%) were coded-wire tagged and released. The outmigration was predominately comprised of age 1 smolts (99.0%).

The adult counting fence was operated between 17th October and 8th December. A portion of the adult coho escapement entered the river uncounted prior to counting fence installation and again during a brief period when the fence was topped on 30th October. In total, 125 adults and 80 jacks were counted entering the system. The assessed adult escapement comprised 60 females and 61 males, resulting in a male:female ratio of 1:0.98.

A total of 120 adults and 75 jacks were marked with anchor tags and an opercular punch to enable an estimate of escapement by mark-recovery. Recovery surveys were conducted between 22nd October and 11th December. The 1997 escapement estimate for adult coho is 1176 (95% confidence interval 684 – 2352). An estimate of jack escapement from recoveries of marks on carcasses is 2181 (95% confidence interval 785 – 3950). An estimate of the total of coded-wire tagged adults (292) was derived from the ratio of clipped to un-clipped live adults counted at the fence, applied to the adult estimate. A similar calculation for jacks is 552 coded-wire tagged individuals.

RÉSUMÉ

Taylor, J.A, Baillie, S.J., and Simpson, K. 2006. 1997 Juvenile and adult enumeration studies of coho salmon at Black Creek, Vancouver Island. Can. Manuscr. Rep. Fish. Aquat. Sci. 2767: *v* + 38 p.

La barrière de dénombrement de la rivière Black a été utilisée en 1997 pour compter deux groupes de saumon coho, soit la descente de smolts et l'échappée de reproducteurs. On a capturé 70 763 smolts entre le 10 avril et le 16 juin 1997, et on a estimé que 5829 autres auraient migré quand la barrière était inexploitable. On a marqué avec des micromarques codées puis libéré 70,395 smolts (91,9 % du nombre total). La descente était composée principalement de smolts d'âge 1 (99,0 %).

Pour les adultes, la barrière de dénombrement a été exploitée du 17 octobre au 8 décembre. Une portion de l'échappée de cohos adultes est entrée dans la rivière sans avoir été dénombrée, avant l'installation de la barrière de dénombrement et aussi le 30 octobre durant une brève période où l'eau est montée par-dessus la barrière. En tout, on a dénombré 125 adultes et 80 grilses qui ont entré dans la rivière. L'échappée d'adultes sexée comprenait 60 femelles et 61 mâles, pour un ratio mâle:femelle de 1:0,98.

On a marqué 120 adultes et 75 grilses avec des marques à ancrage et des perforations operculaires pour permettre une estimation de l'échappée par marquage-récupération. Les travaux de récupération ont été menés du 22 octobre au 11 décembre. L'échappée estimative de saumons cohos adultes pour 1997 est de 1176 individus (intervalle de confiance à 95 % : 684-2352). À partir des marques récupérées sur les carcasses, on a estimé l'échappée de grilses à 2181 individus (intervalle de confiance à 95 % : 785-3950). On a obtenu une estimation du nombre total d'adultes portant des micromarques codées de 292 individus, à partir de la proportion d'adultes vivants dénombrés à la barrière dont la nageoire adipeuse était coupée, proportion qu'on a ensuite appliquée au nombre estimatif d'adultes. Suivant un calcul similaire, on a estimé le nombre de grilses portant des micromarques codées à 552 individus.

INTRODUCTION

This report documents the smolt and adult enumeration programs for coho salmon (*Oncorhynchus kisutch*) at the Black Creek fence in 1997. This year of the study contributes to an uninterrupted data set that has been compiled since 1984. Both the spring and fall programs are based on sampling conducted at the permanent fence site located 100 m upstream of tidal influence, about 40 m downstream from Seaview Road in Miracle Beach Provincial Park.

The spring program is designed to assess the outmigration of coho smolts with respect to numbers, size and age composition and timing of migration. Coded-wire tags are implanted in as many smolts as possible. In previous years sampling has been performed to determine sex ratios of outmigrants, however, this was not done in 1997.

Adult coho returning in the fall are counted at the same location but utilizing a modified fence configuration (Baillie et al. 2004). Spawners are enumerated and sampled for sex, length, age and maturity. Carcasses are sampled and heads are recovered from coded-wire tagged fish. Since 1984, mark-recapture has been the primary method of escapement estimation, since high water levels commonly inundate the fence. Marking is conducted at the fence and recovery of marks takes place in as many as possible accessible areas throughout the watershed. Table 1.1 shows the estimated number of smolt and adult coho enumerated at the fence since the project's inception.

Recoveries of coded wire tagged coho in the escapement are used with catch recoveries and release data to estimate ocean survival and exploitation rates. The utility of the data depends on long-term monitoring of escapements, smolt abundances, survivals, catches, exploitations and escapements. Data from the project, along with other sources, is used to predict coho returns, ocean survival and migration patterns for the south coast of British Columbia.

STUDY AREA

Black Creek is a moderately sized coastal stream located 30km north of Courtenay, on the east coast of Vancouver Island (Fig 1.1). It is approximately 31 km long and flows into the Strait of Georgia at Elma Bay. The watershed area is approximately 81 km^2 (Brown et al. 1996) and predominately comprises agricultural lands with forested areas in the upper catchment. Lower in the watershed, small lakes, of which Northy Lake is the largest, beaver ponds and swampy areas are abundant. These areas contribute to the characteristic humic stained flows in the lower sections via a number of tributaries, the largest being Millar Creek. Discharge is largely dependant on rainfall and irrigation and drainage projects have reduced already low summer flows in Black Creek, so that in summer sections of the creek are dry. In contrast, fall freshets can result in a discharge of up to 60 m^3/s (Labelle 1990). Once the storage capacity of the watershed is reached, the creek responds rapidly to rainfall and prolonged flood events tend to be the norm. In

addition to coho, Black Creek supports populations of coastal cutthroat trout (*O. clarki*), and rainbow trout (*O. mykiss*).

METHODS

PHYSICAL OBSERVATIONS

General weather observations were made daily and recorded as subjective comments on rainfall, cloud cover and wind strength. Measurements of water temperature and river height were normally made each day at about 8:00 AM. Water temperature was taken with a pocket thermometer (± 0.5 ^{O}C) at the fence site. Water level was recorded from a staff gauge (± 0.005 m) located approximately 250 m upstream of the fence.

SMOLT OPERATIONS

Catches from the previous day were removed from the holding boxes at about 8 AM and sorted into buckets, by species. All sampling and tagging was performed on anaesthetised smolts using tricaine methane sulphonate (MS-222) as the anaesthetic. Random length samples were collected by measuring, approximately, every 10th coho smolt. A timing device was used to sound an audible tone at an interval that approximated to the time require to tag 10 smolts. On hearing the tone, the smolt being processed was measured. Weights were collected in conjunction with length measurements during the beginning of the run and again after the peak. During both sample periods, up to 10 lengths and weights (± 0.1 g) were recorded per 5 mm length group. Scale samples were collected in four sampling periods: 12th April to 7th May, 8th May to 21st May, 22nd May to 6th June and 7th June to 16th June. During each sample period a scale smear was taken from up to 10 coho smolts per 5 mm length group. Weight and scale samples were not randomly selected and effort was made to cover the entire size range of smolts.

Age determinations were performed by the Fish Ageing Unit at the Pacific Biological Station in Nanaimo, BC. The age composition of smolts was calculated for each of the four sampling periods after Ketchen's stratified sub-sampling method (Ricker 1975): the age composition of each 5 mm length group was determined in the non-random age sample and this was used to derive the frequency of age classes in the random samples by size group. The proportional age composition by period was determined from the summed frequencies by age over all sizes.

Each smolt had its adipose fin removed before being injected with a CWT, which was applied with either a MK IV or a MK II Tagging Unit (Northwest Marine Technologies, Shaw Island, WA 98286). Tagged coho were placed into a floating holding box to recover from the operation, and released periodically through the day. Untagged coho (those 'rejected' by the quality control device or QCD) were tested for tags a second time and re-tagged if necessary. Moribund fish were released untagged. Tag retention tests were done every 2 weeks to estimate the number of CWT'd coho smolts that lost their tag in the first 24 h. In each test 100-200 coho were held for 48 h and checked for tags using the QCD.

Sequential coded-wire tags were used. Unlike previous years, tag code series were not allocated to large and small size groups of smolts. A total of six series of sequential codes was applied to the 1997 smolt migration.

Other salmonids were noted as to species, fork length (± 1 mm) and whether they had a fin clip. Coho fry were not consistently caught by the screen size used in traps and panels, therefore, totals have not been provided in this report.

ADULT OPERATIONS

A description of the modified adult fence is provided by Baillie et al. (2004). In 1997, the fence was not installed until 17th October. It was operated until removal on 8th December. Physical measurements and weather observations were made as in the spring. The traps were inspected at 8 AM, and periodically through the day as warranted by fish movement. Individual fish were netted from the trap and sampled for post orbital hypural length (POH approximately ±5mm), fork length (FL, approximately ±5mm), sex (female, adult male or jack) and the presence of fin clips or external marks, including hook scars and severe injuries. Jack coho were defined as those fish <40 cm POH.

Every coho was tagged with a numbered anchor tag (FD-94, 2 in., Floy Tag & Manufacturing, Seattle WA, 98105). Both International Orange and clear tag colours were applied. Tags were inserted into the dorsal musculature on the left side of the dorsal fin, between the anterior pterygiophores. A small (7mm) hole was punched in the left operculum of each tagged fish to enable tag loss to be estimated.

Sampling targets for scale samples were set at 3 coho per 1 cm size class for POH classes ≤ 40 cm, and 15 coho per 5 cm size class, for classes > 40 cm. Every tenth adipose-clipped jack was sacrificed and frozen for CWT analysis. Scale samples were taken from these fish also. Due to the small run size, almost all coho were measured for fork length and weight (± 0.05 kg) and had scale samples collected.

Other salmonid species encountered at the fence were identified, sexed and measured for fork length (± 5 mm).

Spawning ground surveys were conducted to census marked adult coho. These surveys were conducted throughout the system, and were predominately directed at the recovery of carcasses. However, recovery of moribund coho was accomplished using an electroshocker. The presence and number of a left opercular punch marks was recorded for all coho. Recoveries were further classified as tagged (Floy tag) untagged or lost tag (opercular punch but no tag). Tag numbers were noted, as were other marks such as adipose clips present or unknown (due to condition of the fish). The heads from adipose clipped carcasses were preserved for CWT analysis. Additional sampling of carcasses included: sex (confirmed by gonad examination), POH length, and subjective assessment of % spawned.

In addition, visual surveys were conducted at a number of index sites used in previous programs (e.g. Bocking et al. 1988, Bocking et al. 1991, Bocking et al. 1992, Irvine et al.

1992). A two person crew counted spawners from the banks of the creek on two occasions: 22nd and 23rd October and 7th and 8th November.

RESULTS

JUVENILE ENUMERATION

Operation of the smolt fence began earlier than usual, on 10th April. Water levels were elevated by greater than average rainfall shortly after commencement of the program and remained higher than normal throughout the rest of the month (Table 2.1 and Fig. 2.1). Flood conditions occurred following a period of heavy rainfall in early May, resulting in a portion of the 1997 smolt outmigration passing downstream uncounted. Between 5th and 10th May the fence was inoperable and panels were removed to permit the unobstructed movement of juveniles. This portion of the migration was estimated to consist of 5829 coho smolts. Estimated daily counts were derived by interpolation from the regression of the natural logarithm of daily counts with time. The function:

$$Y = 0.25 * \text{Ln (number of smolts)} + 2.414 \quad r^2 = 0.94$$

was used to construct the uncounted portion of the smolt migration (Fig. 2.2).

A total of 76,592 coho smolts, including the estimate above for uncounted fish, migrated from Black Creek in 1997. Of these fish, 70,395 were coded-wire tagged using 6 code series. Mortalities were a small (0.1%) proportion of the total tagged. Daily catches of coho and other species are listed in Table 2.2. A summary of catches and tag releases is provided in Table 2.3. The 1997 smolt migration was approximately unimodal (Fig. 2.3), with the peak movement recorded on 17th May, when 5442 smolts were captured. However, similar numbers were also caught on 13th, 14th and 16th May (5136, 5417 and 5347). An increase in water levels in early June had an associated small increase in smolt movement.

Tag retention was estimated from a total of 1021 coho smolts that were held for a two day period before release. Only 6 fish lost their tags, resulting in a 99.4% retention rate.

Biological sampling

The overall age-length distribution of the outmigration is illustrated in Fig. 2.4 and given in Table 2.4 for each sampling period. Age 1 smolts predominated, representing 99.9% of the total smolts in all age samples. Age 2 smolts were present only in low numbers in any sampling period and no age 3 smolts were encountered. The proportional contributions to the outmigration made by age 2 fish ranged from 0% to 7.1% in periods 4 and 3, respectively.

The mean fork length of the outmigration was 124.6 mm (SD 20.05, range 88 – 204 mm, n = 491). The mean weight of all smolts was 21.8 g (SD 9.71, range 6.4 – 58.3 g, n=230). A weight-length relationship for all measured smolts was constructed as below:

$$\text{Ln(weight)} = 2.87\ (\text{Ln(length)}) - 10.85 \qquad r^2=0.98$$

Other species

Coastal cutthroat trout (*O. clarki*), and rainbow trout (*O. mykiss*) were the only other species enumerated at the fence in 1997. In total, 187 cutthroat trout were captured, of which 33 were clipped hatchery fish. The mean fork length of cutthroat trout was 190.6 mm (SD 67.6, range 95 – 450 mm, n=187). A total of 19 rainbow trout was captured (mean length 208.2 mm, SD 19.1, range 165 – 240 mm, n=19).

ADULT ENUMERATION

Physical Observations

Rainfall during the period of fence operation totalled 286.6 mm with greatest volumes in November. Almost as much rain fell in the first half of October, prior to fence installation (249.6 mm), as in the entirety of the program.
Daily water temperature and water height data are provided in Table 3.1 and Fig. 3.1. Mean water temperature during the study was 11.0 °C (range 7.0°C to 15.0 °C).

Adult escapement

As a result of the unusually wet summer, Black Creek water levels were sufficiently high to permit passage of coho from approximately mid-August. Therefore, some part of the 1997 escapement entered the system uncounted prior to installation of the counting fence on 17th October. However, coho were not encountered at the fence until 29th October when rainfall provided an increase in water levels that peaked at 131 cm (Fig. 3.2). A majority of the counted escapement moved into Black Creek during this period of high water. The fence was topped briefly on 30th October but was operational again on the following morning. A second, smaller pulse of coho corresponded to elevated water levels in late November. In total, 121 adult coho (males and females) were sampled at the fence and four adults were counted passing over the fence during the flooding on 30th October. The total number of jacks counted at the fence was 80 of which 3 were sacrificed for CWT recovery. International Orange tags were applied to 69 adults and 41 jacks. Clear tags were applied to 51 adults and 34 jacks. The assessed adult escapement comprised 60 females and 61 males, resulting in a male:female ratio of 1:0.98. Daily escapement totals are provided in Table 3.2.

Biological sampling

The length-frequency distribution of the escapement is illustrated in Fig. 3.3. The mean fork length of adult coho (males and females combined) was 56.4 cm (SD=9.29, range 35.5 – 76, n=120), and mean POH was 46.0 cm (SD=6.73, range 34.6 – 62.0, n=120). Mean weight was 2.35 kg (SD=1.12, range 0.8 – 5.45, n=117). Equivalent data for males and females are summarized in Table 3.3. Mean fork length of jack coho was 32.4 cm (SD=3.25, range 26.5 – 42.7, n=79) and mean POH was 25.9 cm (SD=2.57, range 20.8 –

34.2, n=79). The mean weight of jack coho was 0.47kg (SD=0.18, range 0.25 – 1.5, n=54).

Linear regression of POH on fork length, by sex, is:

Males	(FL) = 1.274 (POH) (95% confidence range 1.163 – 1.386)
Females	(FL) = 1.229 (POH) (95% confidence range 1.154 – 1.303)
Jacks	(FL) = 1.200 (POH) (95% confidence range 1.108 – 1.292)

Scale samples were taken from 252 coho at the counting fence. From this sample 99 were successfully aged. Table 3.4 shows the aging results with proportional expansions to the estimated population. The low success rate on the aging work was due to a large number of regenerated scales that are missing early circuli. This problem is caused by scale loss by the fish during the fry or smolt stage resulting in scale re-growth, or regeneration. The new scale does not exhibit circuli or annuli and therefore age cannot be determined (Shayne MacLellan, DFO Aging Lab Supervisor, pers. com.).

Mark-recapture

Surveys were conducted between 22nd October and 11th December to recover coho carcasses. A total of 59 adults and 25 jacks were examined for marks and fin clips. No adult or jack coho were found to have tags or opercular punches. Additional carcass recoveries were made at the counting fence between 1st November and 2nd December. Seven marks were recovered from a total of 21 adults, and we recovered four marks from 85 jacks.

Visual surveys resulted in counts of 92 adults, including two tagged coho. Only the more visible orange tags were observed. All of the fish were seen during the second set of surveys.

An estimate of escapement was constructed from carcass data, collected at the fence and upstream locations, using the Bayesian method (Gazey and Staley 1986). The calculation of escapement was based on recoveries of marks on carcasses to eliminate the under-reporting of clear tags in visual surveys and to eliminate correction for tag loss: all carcasses that were recovered with an operculum punch carried a tag. The mode of the population estimate for adult coho was located at 1173 - 1179 (95% HPD 684 – 2352). The posterior probability distribution was constructed from 801 discrete population levels between bounds of 150 – 4150 fish. The estimate for jacks was 2181 (95% HPD 785 – 3950). The posterior probability distribution was constructed from 801 discrete population levels between bounds of 250 – 4250 fish.

Given the limitation of the biased tag application and incomplete carcass recovery we rounded the estimates to two significant digits. This results in an estimate of 1200 adults and 2200 jacks.

Coded-Wire Tag recoveries

Adipose clips, indicating the presence of coded wire nose tags, were encountered on 30 adult coho (24.8%) and 20 jacks (25.3%) (Table 3.5). Five adults (8.5%) recovered in upstream surveys were adipose-clipped, while no adipose clips were found on the adult carcasses recovered from the fence. The adipose clip rate in jack carcasses recovered from the fence (27.1%) was greater than that encountered on carcasses recovered upstream (20.0%) and similar to the clip rate on live jacks enumerated at the fence.

The total number of CWT adults in the escapement was estimated using the ratio of adipose fin clips determined from live fish expanded to the Bayes escapement estimate (292 adults). The total estimate for adipose clipped jacks of 552 individuals was derived similarly. Table 3.6 presents the results of CWT codes extracted from sacrificed Jack coho and carcass deadpitch, summarized in Table 3.7.

Table 3.8 shows which fisheries the 1994 brood CWT release from Black creek were extracted from the 1999 coho stock status document by Simpson et al., 1999.

DISCUSSION

The 1997 smolt output from Black Creek was the fourth highest total recorded for the system (Baillie et al. 2004) and was smaller only than counts in 1988, 1990 and 1994. Correcting for tag loss (0.06%) provides a total of 69,973 effective releases from catches of 70,395 smolts. The tagged releases represent 91.4% of an estimated outmigration of 76,592 smolts.

The proportion of age 1 smolts in the 1997 outmigration was 99.0%, similar to the proportion noted in 1996 (99.3%) by Baillie et al. (2004). No age 3 smolts were encountered in 1997. Most age 2 smolts migrated in the first and second periods of movement, 20 and 30 individuals respectively, rather than early in the program as described by Nelson et al. (1995). While we have no information on the age structure of the uncounted migrants, the timing of migration for the age 2 fish would not be significantly altered by these data since flooding spanned the end of period 1 and the start of period 2 (5^{th} May – 10^{th} May).

The overall run timing in 1997 was later than in recent years. The quartiles of migration timing are illustrated in Figure 2.6 for the years 1994 – 1997. Of these, the current year was the latest during this period, but the outmigration was also the least prolonged. In 1997 50% of the smolt output occurred during an eight day period between 14^{th} May and 22^{nd} May, in comparison with 15 days (8^{th} - 23^{rd} May) in 1996.

The adult program was unusual in that early precipitation gave adult and jack coho access to Black Creek from, approximately, mid-August until installation of the counting fence on 17^{th} October. Comparison of the fence counts with the Bayesian estimate of adult escapement, 1176 individuals, suggests that approximately 89% of the run entered Black Creek uncounted. For jacks the percentage is even greater (96%), in agreement with data

from other years of the program that show the jack movement tends to be concentrated in the early portion of the run (e.g. Baillie et al. 2004). Almost all of these fish escaped prior to installation of the fence. During flooding on 30th October, a small number of adults may have entered the system un-observed, however, only four coho were counted jumping over the fence on this date.

The 1997 adult escapement was a substantial improvement over the 284 adults recorded in 1996, but represented only 70% of the average escapement (1691) between 1990 and 1995 (Baillie et al. op. cit.). Similarly, only 329 jacks were counted in 1996, in comparison to an average estimated escapement of 1700 in the previous 6 years: the 1997 estimate is 128% of the average. However, the adult and jack 1997 escapement estimates likely underestimate true escapement in both cases. Both carcass recoveries and visual surveys suggest that marks were not fully integrated into the overall population. No marks were found on 59 recoveries from various sites in Black Creek, in contrast to a 33% mark recovery at the fence. This likely resulted from limited tag application to what was effectively the later stage of the escapement. A majority of tagged fish may not have moved as far upstream into the system as the earlier portion of the escapement and, therefore, would have had a greater potential to be washed down onto the fence and recovered. Visual observations of live coho also suggest that tagged fish were not uniformly distributed, with only two tagged adults recorded from one site in the system from a total of 92 fish counted in 8 locations. Although 43% of the tags released were colourless and designed to reduce the bias associated with greater visibility of tagged fish in carcass recoveries, this would not be expected to have substantively changed the above observations.

The proportional returns from the adult and jack brood years of 1995 and 1996, respectively, were calculated from total CWT releases divided by the calculated CWT estimates for 1997. In 1995, a total of 18,208 smolts were released with tags (Nelson and Simpson 1996), of which 1.60% (292 adults) returned in 1997. Similarly, the 1997 estimate of 552 tagged jacks represents 3.99% of the 13,828 tagged smolt releases from 1996 (Baillie et al. op. cit.).

ACKNOWLEDGEMENTS

We thank Jim Hunter and Jim Amos who conducted fence operations and surveys of the watershed. We also thank Don Bolivar and Caroline Melville who assisted with fence cleaning and sampling during high water.

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GENERAL TABLES AND FIGURES

Table 1.1 Enumeration of Coho Smolts and Adults, 1984-1997

Year	Juveniles		Adults	
	Smolts	Jacks[1]	Males	Females
1984	N/A	350	3175[2]	2815[2]
1985	50208	349	3176[2]	2816[2]
1986	38212[3]	483	2385	2433
1987	60909[3]	1071	422	363
1988	75401	396	1848	1274
1989	29862	613	1607	1665
1990	118897	1328	524	713
1991	53876	2373	1719	1849
1992	50271	2348	904	816
1993	65171	1502	570	389
1994	78282	1500	484	416
1995	18295	1150	850	910
1996	14178	678	158	126
1997	76592	552	593	583

[1]- early counts of jacks are biased low, due to undetected passage of jacks through the fence panels

[2] - estimated proportions of males and females

[3] - wild population supplemented by fry planting in previous summer

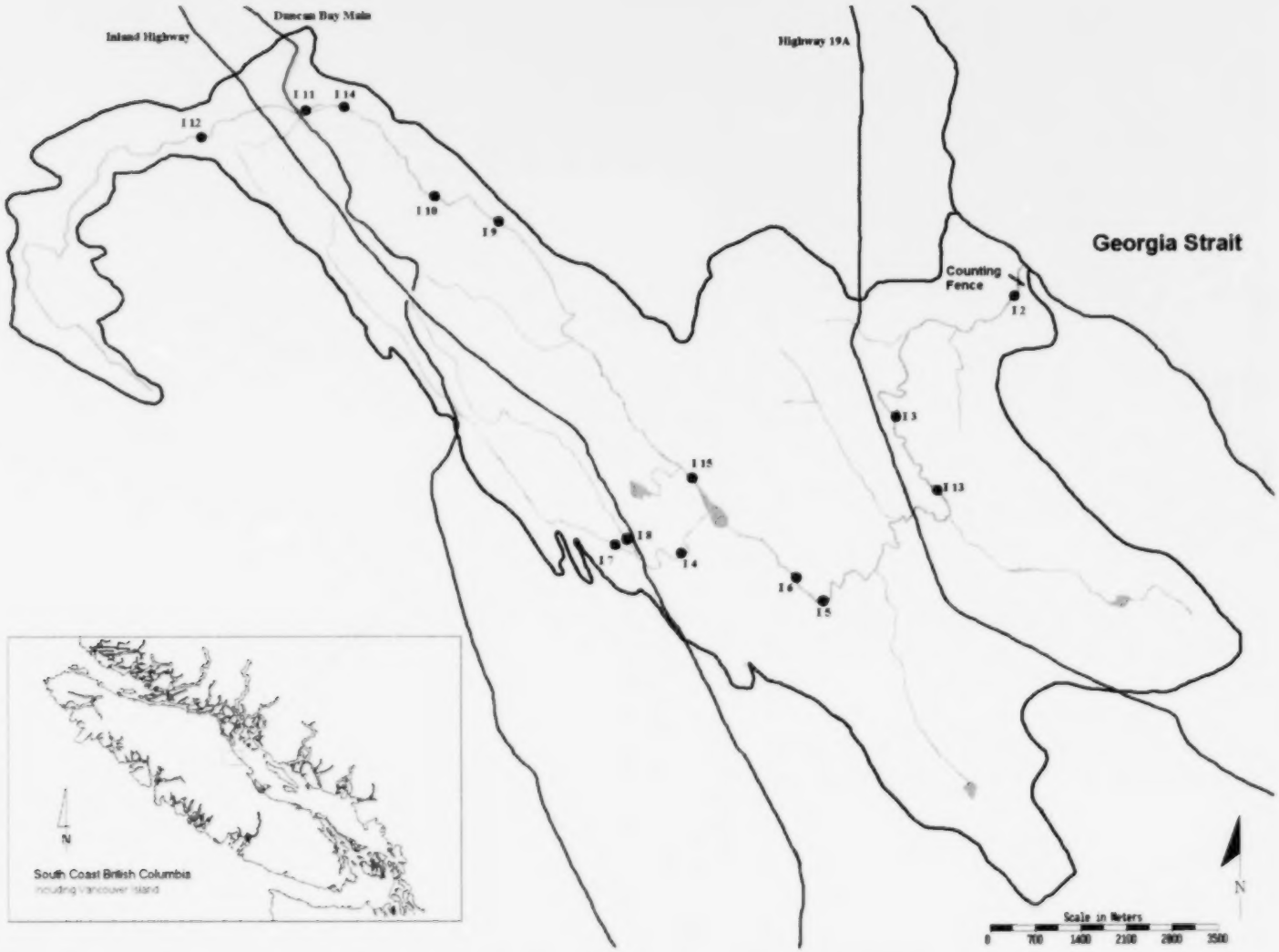

Figure 1.1 Map of Black Creek and Vancouver Island, showing water course, watershed boundary, location of fence, recovery sampling sites and major roads.

BLACK CREEK SPRING 1997 OPERATIONS

TABLES AND FIGURES

Table 2.1 Daily water temperature (^{0}C) and water height (cm)

Date	Water temperature	Water height
10-Apr-97	7.5	54
11-Apr-97	7.0	46
12-Apr-97	8.0	49
13-Apr-97	8.0	50
14-Apr-97	7.0	50
15-Apr-97	8.0	49
16-Apr-97	8.0	95
17-Apr-97	8.0	88
18-Apr-97	8.5	79
19-Apr-97	8.5	73
20-Apr-97	8.0	87
21-Apr-97	8.0	79
22-Apr-97	8.5	72
23-Apr-97	9.0	77
24-Apr-97	9.0	71
25-Apr-97	10.0	68
26-Apr-97	9.5	78
27-Apr-97	8.5	76
28-Apr-97	9.5	69
29-Apr-97	9.0	73
30-Apr-97	9.0	70
01-May-97	8.5	70
02-May-97	9.0	65
03-May-97	9.5	64
04-May-97	9.5	81
05-May-97	9.5	118
06-May-97	9.0	119
07-May-97	9.0	110
08-May-97	9.5	95
09-May-97	10.5	81
10-May-97	11.5	74
11-May-97	12.0	65
12-May-97	13.0	60
13-May-97	14.5	57
14-May-97	15.0	54
15-May-97	15.0	51
16-May-97	14.5	48
17-May-97	13.5	46
18-May-97	13.0	44

Table 2.1 (cont'd)

Date	Water temperature	Water height
19-May-97	12.5	42
20-May-97	12.5	40
21-May-97	11.5	38
22-May-97	10.5	40
23-May-97	10.0	40
24-May-97	11.5	41
25-May-97	11.5	40
26-May-97	12.5	39
27-May-97	13.0	39
28-May-97	13.5	37
29-May-97	13.5	39
30-May-97	13.5	47
31-May-97	14	61
01-Jun-97	13.5	58
02-Jun-97	12.5	52
03-Jun-97	13	49
04-Jun-97	13	61
05-Jun-97	13	60
06-Jun-97	13.5	56
07-Jun-97	13	51
08-Jun-97	12.5	50
09-Jun-97	12.5	49
10-Jun-97	13	46
11-Jun-97	14	44
12-Jun-97	13.5	43
13-Jun-97	14	42
14-Jun-97	14.5	41
15-Jun-97	15	38
16-Jul-97	15	37

Table 2.2 Daily catches of coho smolts and other species at the Black Creek fence, 1997

Date	COHO					CTT		RBT
	Total	presample morts	CWT'd released	CWT'd morts	unCWT'd	with clip	no clip	
09-Apr-97	0							
10-Apr-97	0							
11-Apr-97	0						2	
12-Apr-97	1		1				2	
13-Apr-97	0							
14-Apr-97	0					1	3	
15-Apr-97	5		5			1	5	
16-Apr-97	0							
17-Apr-97	0							
18-Apr-97	0							
19-Apr-97	0							
20-Apr-97	0							
21-Apr-97	41	26	15					
22-Apr-97	7	1	6					
23-Apr-97	18		18					
24-Apr-97	56	3	53					
25-Apr-97	80		80				3	
26-Apr-97	58	2	56				8	
27-Apr-97	83	3	80				1	1
28-Apr-97	52		52				1	
29-Apr-97	76		76				2	
30-Apr-97	93	2	91				1	
01-May-97	199		198	1			1	
02-May-97	173	1	169	3			1	
03-May-97	160	1	159				1	
04-May-97	278		278				3	
05-May-97	475		0		475[a]			
06-May-97	611		0		611[a]			
07-May-97	784		0		784[a]			
08-May-97	1007		0		1007[a]			
09-May-97	1292		0		1292[a]			
10-May-97	1660		0		1660[a]			
11-May-97	1753	12	1739	2			2	
12-May-97	4251	40	4208	3			15	1
13-May-97	5136	5	5122	9			7	1
14-May-97	5417	50	5357	10			2	
15-May-97	4762	30	4711	21			10	1
16-May-97	5347	6	5340	1			5	

Table 2.2 (cont'd.)

Date	COHO					CTT		RBT
	Total	presample morts	CWT'd released	CWT'd morts	unCWT'd	with clip	no clip	
17-May-97	5442	5	5436	1			11	
18-May-97	4753	4	4741	8			7	1
19-May-97	2212	5	2202		5		4	1
20-May-97	4620	6	4606	5	3		10	
21-May-97	2672	3	2669				6	
22-May-97	4401	12	4387	1	1		16	
23-May-97	2003	4	1995		4		4	
24-May-97	1801	5	1795		1			
25-May-97	1581	6	1571		4		1	
26-May-97	1832	5	1822		5		2	
27-May-97	1837		1836	1			2	
28-May-97	1057	2	1047	2	6		2	
29-May-97	779	5	771	1	2		6	1
30-May-97	1055	3	1048		4		2	
31-May-97	1413	1	1411		1			
01-Jun-97	1826	1	1823		2		1	1
02-Jun-97	1377	2	1375					
03-Jun-97	184		183	1				
04-Jun-97	612		611		1		2	
05-Jun-97	386		385		1		1	
06-Jun-97	177		177				2	
07-Jun-97	203	2	200		1			
08-Jun-97	137		137				1	
09-Jun-97	65		63		2			
10-Jun-97	58		57		1			
11-Jun-97	72		72					
12-Jun-97	74		74					
13-Jun-97	49		49				3	
14-Jun-97	18		17		1			
15-Jun-97	8		8					
16-Jun-97	13		13					
Totals	76592	253	70395	70	5874	2	158	8

[a] Number of coho smolts that were estimated to have moved past the fence during high water.

Table 2.3 Catches and coded-wire tag releases of coho smolts by tag code and sampling date

Tag Series	Sampling Date	Total Catch	Fence/Trap Mortalities	Coded-wire tag mortalities	Coded-wire tag releases	Untagged releases
080710	9/4 – 13/5	16680[1]	94	18	10737	5829
081012	13/5 – 15/5	11434	79	31	11323	0
080913	15/5 – 20/5	22788	29	15	22739	8
080912	21/5 – 24/5	10877	24	1	10846	6
080815	25/5 – 1/6	11380	23	4	11329	24
080162	2/6 – 16/6	3433	4	1	3421	7
Totals		76592	253	70	70395	5874

[1] includes an estimated 5829 smolts that migrated past the fence in high water.

Table 2.4 Age distribution of coho smolts by sampling period

Proportional representation of age was calculated from non-random sampling within length classes and extrapolated to the randomly sampled portion of the population.

Period 1: 12 April – 7 May 1997

Length range (mm)	No. sampled for ageing	Measured ages		Random sample	Calculated ages	
		Age 1	Age 2		Age 1	Age 2
75-79	0	0	0	0	0	0
80-84	0	0	0	0	0	0
85-89	0	0	0	0	0	0
90-94	1	1	0	4	4	0
95-99	1	1	0	9	9	0
100-104	5	5	0	57	57	0
105-109	8	7	1	65	57	8
110-114	10	9	1	83	75	8
115-119	10	10	0	84	84	0
120-124	13	13	0	72	72	0
125-129	14	14	0	57	57	0
130-134	13	13	0	52	52	0
135-139	10	10	0	31	31	0
140-144	13	13	0	14	14	0
145-149	11	9	2	10	8	2
150-154	12	12	0	5	5	0
155-159	1	1	0	2	2	0
160-164	2	0	2	0	0	0
165-169	2	0	2	0	0	0
170-174	5	2	3	3	1	2
175-179	4	0	4	0	0	0
180-184	1	0	1	0	0	0
185-189	5	0	5	0	0	0
190-194	2	0	2	0	0	0
195-199	0	0	0	0	0	0
200-204	1	0	1	0	0	0
Total	144	120	24	548	528	20
	% by age class				96.3%	3.7%

Table 2.4 (cont'd.)

Period 2: 8 May - 21 May 1997

Length range (mm)	No. sampled for ageing	Measured ages Age 1	Measured ages Age 2	Random sample	Calculated ages Age 1	Calculated ages Age 2
75-79	0	0	0	1	1	0
80-84	0	0	0	3	3	0
85-89	1	1	0	12	12	0
90-94	7	7	0	64	64	0
95-99	10	10	0	227	227	0
100-104	9	9	0	466	466	0
105-109	14	14	0	571	571	0
110-114	10	10	0	536	536	0
115-119	12	12	0	432	432	0
120-124	13	12	1	344	318	26
125-129	14	14	0	189	189	0
130-134	13	13	0	125	125	0
135-139	13	13	0	64	64	0
140-144	12	11	1	22	20	2
145-149	4	4	0	9	9	0
150-154	0	0	0	1	1	0
155-159	0	0	0	1	1	0
160-164	0	0	0	0	0	0
165-169	0	0	0	1	0	1
170-174	0	0	0	0	0	0
175-179	0	0	0	0	0	0
180-184	0	0	0	1	0	1
185-189	0	0	0	0	0	0
190-194	0	0	0	0	0	0
195-199	0	0	0	0	0	0
200-204	0	0	0	0	0	0
Total	132	130	2	3065	3035	30
		% by age class			99.0%	1.0%

Table 2.4 (cont'd.)

Period 3: 22 May – 6 June 1997

Length range (mm)	No. sampled for ageing	Measured ages Age 1	Measured ages Age 2	Random sample	Calculated ages Age 1	Calculated ages Age 2
75-79	0	0	0	0	0	0
80-84	0	0	0	0	0	0
85-89	1	1	0	9	9	0
90-94	8	8	0	49	49	0
95-99	8	8	0	208	208	0
100-104	9	9	0	412	412	0
105-109	9	9	0	513	513	0
110-114	9	9	0	355	355	0
115-119	6	6	0	229	229	0
120-124	5	5	0	114	114	0
125-129	7	7	0	65	65	0
130-134	11	11	0	31	31	0
135-139	9	9	0	16	16	0
140-144	11	11	0	5	5	0
145-149	7	7	0	2	2	0
150-154	2	2	0	0	0	0
155-159	0	0	0	1	1	0
160-164	0	0	0	0	0	0
165-169	0	0	0	0	0	0
170-174	0	0	0	0	0	0
175-179	0	0	0	0	0	0
180-184	0	0	0	0	0	0
185-189	0	0	0	0	0	0
190-194	0	0	0	1	0	1
195-199	0	0	0	0	0	0
200-204	0	0	0	0	0	0
Total	102	102	0	2010	2009	1
	% by age class				100.0%	0.0%

Table 2.4 (cont'd.)

Period 4: 7 June – 16 June 1997

Length range (mm)	No. sampled for ageing	Measured ages		Random sample	Calculated ages	
		Age 1	Age 2		Age 1	Age 2
75-79	0	0	0	0	0	0
80-84	0	0	0	0	0	0
85-89	0	0	0	0	0	0
90-94	0	0	0	0	0	0
95-99	0	0	0	3	3	0
100-104	3	2	1	16	11	5
105-109	11	11	0	23	23	0
110-114	4	4	0	17	17	0
115-119	5	5	0	13	13	0
120-124	3	3	0	1	1	0
125-129	2	2	0	2	2	0
130-134	0	0	0	0	0	0
135-139	0	0	0	0	0	0
140-144	0	0	0	0	0	0
145-149	0	0	0	0	0	0
150-154	0	0	0	0	0	0
155-159	0	0	0	0	0	0
160-164	0	0	0	0	0	0
165-169	0	0	0	0	0	0
170-174	0	0	0	0	0	0
175-179	0	0	0	0	0	0
180-184	0	0	0	0	0	0
185-189	0	0	0	0	0	0
190-194	0	0	0	0	0	0
195-199	0	0	0	0	0	0
200-204	0	0	0	0	0	0
Total	28	27	1	75	70	5
	% by age class				92.9%	7.1%

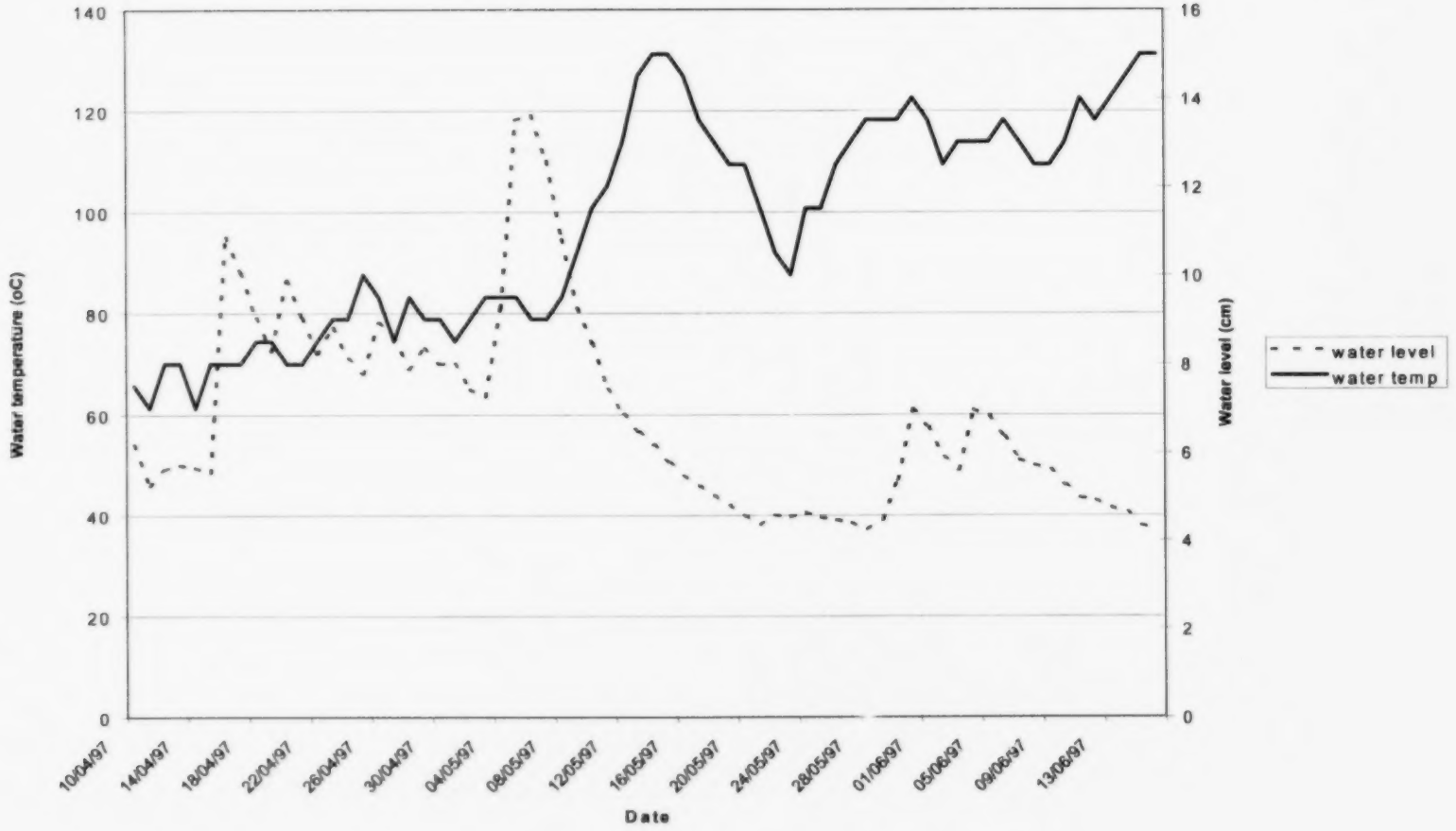

Figure 2.1 Stream conditions during the 1997 smolt outmigration

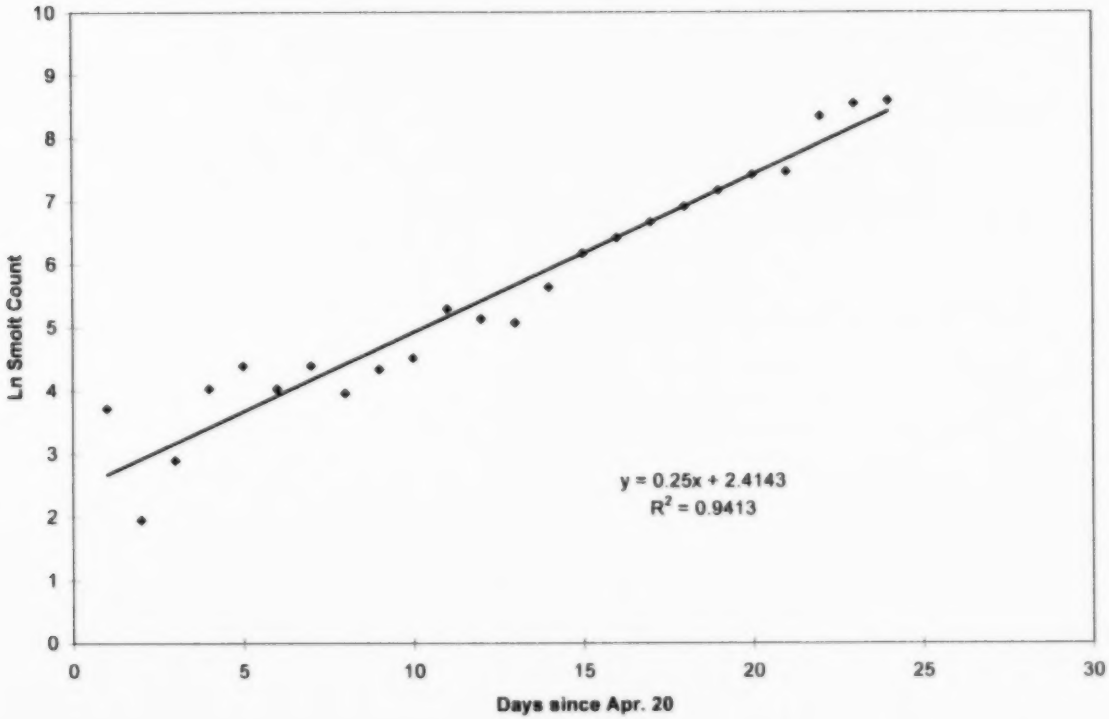

Figure 2.2 Interpolation of daily smolt abundance from regression of Ln daily counts with time

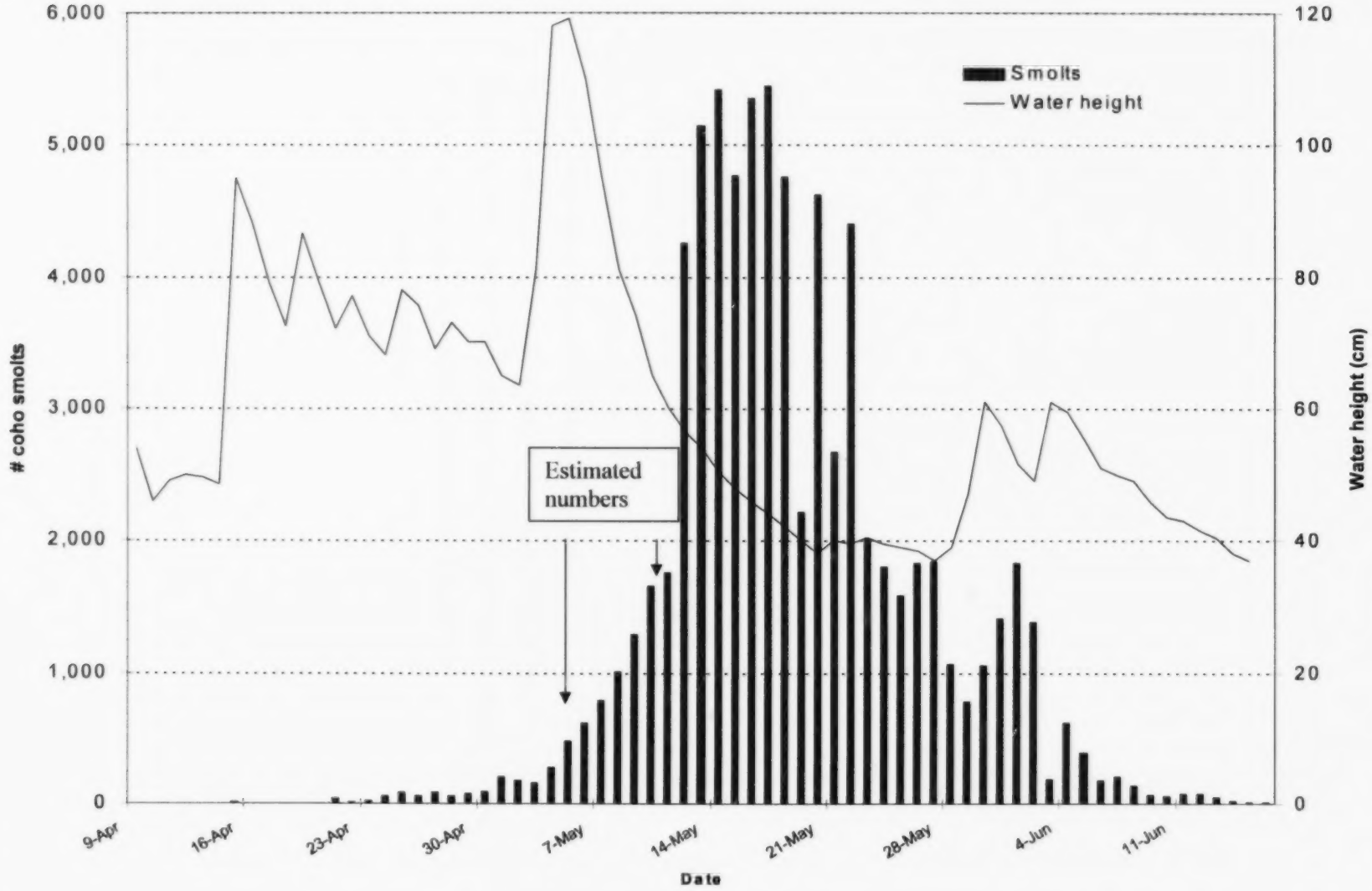

Figure 2.3 Daily smolt outmigration from Black Creek and water levels during the study, 1997

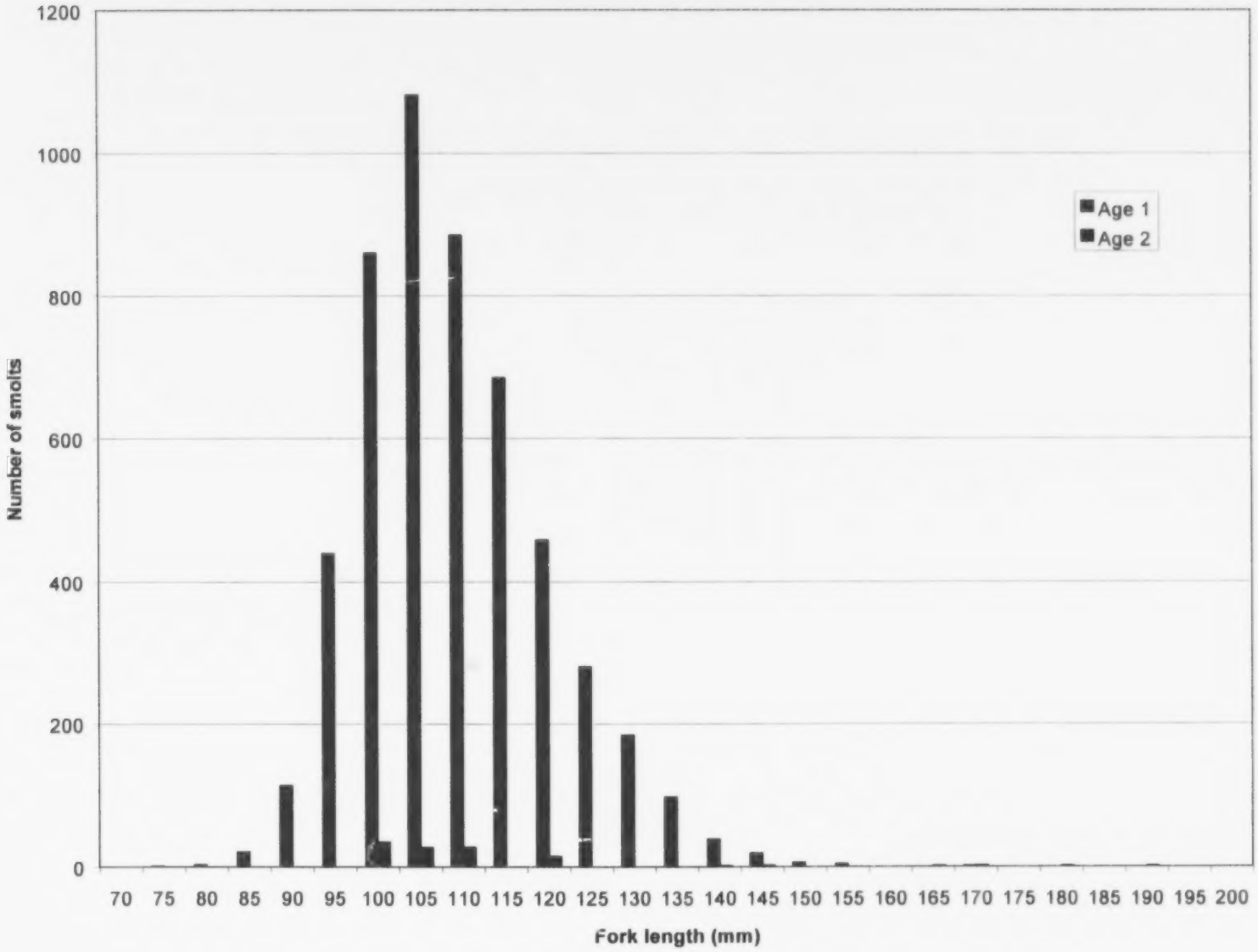

Figure 2.4 Calculated age-length frequency for the 1997 smolt outmigration

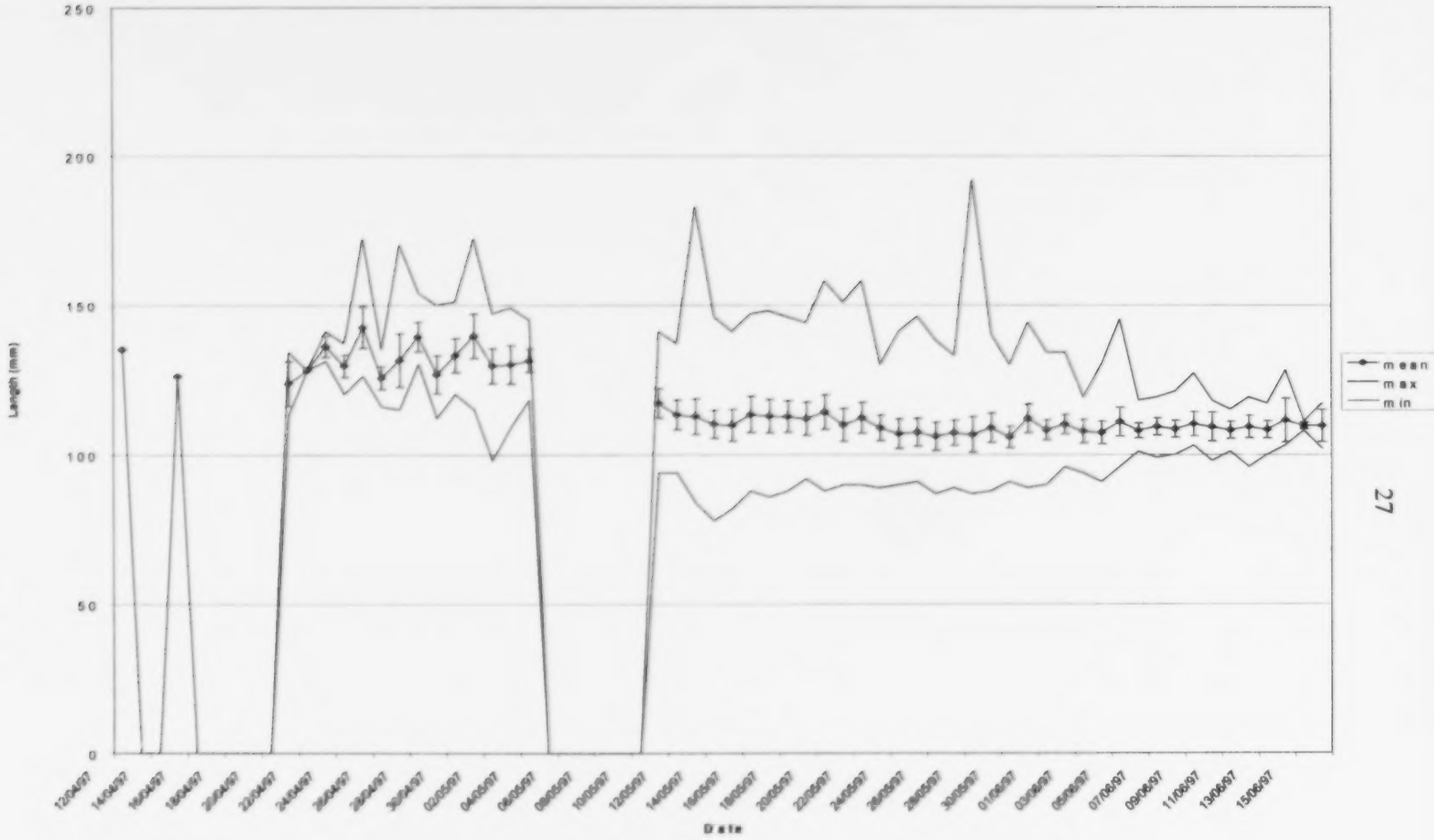

Figure 2.5 Mean daily fork length (one standard deviation is shown) and size range of coho smolts

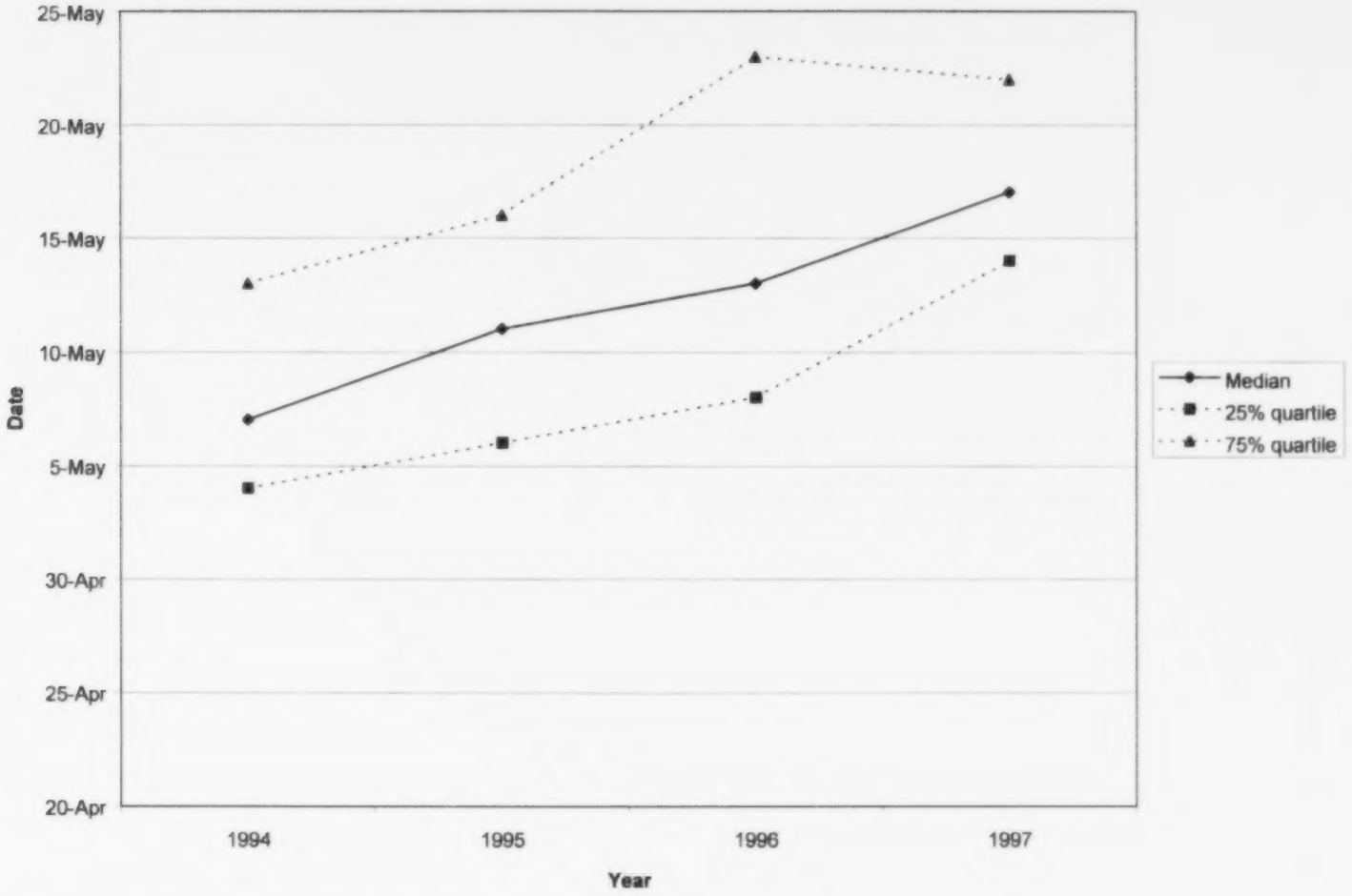

Figure 2.6 Quartiles of migration timing for the smolt output between 1994 and 1997

BLACK CREEK FALL 1997 OPERATIONS

TABLES AND FIGURES

Table 3.1 Daily water temperature (^{0}C) rainfall (mm) and water height (cm) during the fall, 1997

Date	Water Temperature	Precipitation	Water height
18-Oct-97	-	0	80.0
19-Oct-97	-	0	74.5
20-Oct-97	7.0	0	72.0
21-Oct-97	7.0	20	68.0
22-Oct-97	8.0	6	65.5
23-Oct-97	7.0	0	64.0
24-Oct-97	6.5	32	59.0
25-Oct-97	8.0	0	58.5
26-Oct-97	8.5	28	58.0
27-Oct-97	8.5	0	58.0
28-Oct-97	8.0	377	57.0
29-Oct-97	8.5	248	96.0
30-Oct-97	9.5	104	131.0
31-Oct-97	8.5	6	117.0
1-Nov-97	8.0	0	116.0
2-Nov-97	8.5	204	94.0
3-Nov-97	9.0	52	106.0
4-Nov-97	9.0	38	103.0
5-Nov-97	9.5	140	97.0
6-Nov-97	10.0	54	100.0
7-Nov-97	9.0	8	95.5
8-Nov-97	9.5	0	89.5
9-Nov-97	8.5	0	83.0
10-Nov-97	6.8	0	77.0
11-Nov-97	6.0	0	73.0
12-Nov-97	4.5	0	68.5
13-Nov-97	5.0	0	66.0
14-Nov-97	4.5	0	63.5
15-Nov-97	3.5	0	61.0
16-Nov-97	3.5	20	59.0
17-Nov-97	4.5	24	58.0
18-Nov-97	5.0	14	58.5
19-Nov-97	5.0	16	57.5
20-Nov-97	5.5	16	57.5
21-Nov-97	4.0	0	56.5
22-Nov-97	5.0	338	55.5
23-Nov-97	6.5	283	98.0
24-Nov-97	6.5	16	127.5

Table 3.1 (cont'd)

Date	Water Temperature	Precipitation	Water height
25-Nov-97	5.5	16	123.0
26-Nov-97	6.0	20	107.0
27-Nov-97	6.5	420	92.5
28-Nov-97	7.0	208	112.0
29-Nov-97	6.8	90	120.0
30-Nov-97	6.0	0	124.0
1-Dec-97	6.0	8	112.0
2-Dec-97	6.0	0	100.0
3-Dec-97	4.5	8	88.0
4-Dec-97	5.5	0	80.0
5-Dec-97	4.0	0	74.0
6-Dec-97	5.0	0	69.0
7-Dec-97	5.5	52	66.0
8-Dec-97	4.5	0	70.0

Table 3.2 Daily escapement totals for adult and jack coho, 1997

Date	Female	Male	Total adults	Total to date	Jacks	Total to date
27-Oct-97	0	0	0	0	0	0
28-Oct-97	0	0	0	0	0	0
29-Oct-97	32	37	69	69	45	45
30-Oct-97	0	0	4	73	0	45
31-Oct-97	6	7	13	86	15	60
01-Nov-97	2	2	4	90	6	66
02-Nov-97	0	0	0	90	3	69
03-Nov-97	6	7	13	103	5	74
04-Nov-97	4	1	5	108	2	76
05-Nov-97	2	0	2	110	0	76
06-Nov-97	1	0	1	111	1	77
07-Nov-97	0	0	0	111	0	77
08-Nov-97	0	0	0	111	0	77
09-Nov-97	0	0	0	111	0	77
10-Nov-97	0	0	0	111	0	77
11-Nov-97	0	0	0	111	0	77
12-Nov-97	0	0	0	111	0	77
13-Nov-97	0	0	0	111	0	77
14-Nov-97	0	0	0	111	0	77
15-Nov-97	0	0	0	111	0	77
16-Nov-97	0	0	0	111	0	77
17-Nov-97	0	0	0	111	0	77
18-Nov-97	0	0	0	111	0	77
19-Nov-97	0	0	0	111	0	77
20-Nov-97	0	0	0	111	0	77
21-Nov-97	0	0	0	111	0	77
22-Nov-97	0	0	0	111	0	77
23-Nov-97	3	3	6	117	3	80
24-Nov-97	1	1	2	119	0	80
25-Nov-97	1	0	1	120	0	80
26-Nov-97	0	0	0	120	0	80
27-Nov-97	0	0	0	120	0	80
28-Nov-97	0	0	0	120	0	80
29-Nov-97	2	2	4	124	0	80
01-Dec-97	1	0	1	125	0	80
Totals	61	60	125[1]		80	

[1] Includes 4 adults counted but not examined on 30th October during high water

Table 3.3 Summary of fork and post-orbital hypural (POH) length for adult and jack coho

	Fork Length (cm)			POH (cm)		
Sex	Mean	SD	n	Mean	SD	n
Male	55.2	9.29	60	44.7	6.97	59
Female	57.7	7.89	60	47.2	6.26	60
Adults	56.4	8.67	120	46.0	6.73	120
Jacks	32.4	3.25	79	25.9	2.57	79

Table 3.4 Summary of age results of Black Creek coho

	Jacks		Males		Females	
Age	Sample	Escapement	Sample	Escapement	Sample	Escapement
1.0	38	2144				
2.0	1	56				
1.1			25	540	26	483
2.1			3	65	6	112

Table 3.5 Summary of adipose clipped adult coho by sex and mark type, Black Creek.

Sex	# examined	Adipose clipped	Not adipose clipped
M	61	15	46
F	60	15	45
J	79	20	59
Adults (M+F)	121	30	91

Table 3.6 Coded-wire tag recovery in Black Creek coho escapement

Sample type	Tag #	Code
Jack Sac	BC 001	081012
Jack Sac	BC 002	081012
Jack Sac	BC 003	080710
Jack Sac	BC 004	081013
Jack Sac	BC 005	080912
Jack Sac	BC 006	No Pin
Jack Sac	BC 007	No Pin
Jack Sac	BC 008	080710
Jack Sac	BC 009	No Pin
Jack Sac	BC 011	080814
Jack Sac	BC 012	080710
Jack Sac	BC 014	No Pin
Jack Sac	BC 015	080710
Jack Sac	BC 017	080913
Jack Sac	BC 018	081013
Jack Sac	BC 020	No Pin
Jack Sac	BC 023	080913
Jack Sac	BC 024	081012
Jack Sac	BC 025	No Pin
Jack Sac	BC 026	080710
Jack Sac	BC 027	080710
Jack Sac	BC 028	081013
Jack Sac	BC 029	080710
Jack Sac	BC 030	081012
Jack Sac	BC 031	080710
Jack Sac	BC 032	No Pin
Jack Sac	BC 033	081012
Jack Sac	BC 034	080710
Jack Sac	BC 035	No Pin
Carcass	BC 010	No Pin
Carcass	BC 013	080814
Carcass	BC 016	080813
Carcass	BC 019	080814
Carcass	BC 021	No Pin
Carcass	BC 022	080912

Table 3.7 Summary of CWT recoveries

Brood	Code	Jack Sacrifice	Carcass Recovery
1995	080710	9	
1995	080912	1	1
1995	080913	2	
1995	081012	5	
1995	081013	3	
1994	080813		1
1994	080814	1	2
	No Pin	8	2
	Total	29	6

Table 3.8 Estimate of return of CWT Black Creek coho in 1997

Tagged Release		13736
Escapement		235
Catch Region		
FWSP	FWSP	
Net	CN	1
	FGN	
	GSN	
	JFN	
	JSN	27
	NN	
	SWVN	
Sport	ACSPT	
	CSPT	16
	GSPTN	14
	GSPTS	
	JFSPT	46
	WSPT	
Troll	GSTR	
	NCTR	
	NTR	13
	NWTR	
	SCTR	213
	SWTR	
US	AK	5
	US south	27
Total Return		597
Total Catch		362
Survival		4.3%
Exploitation Rate		60.6%

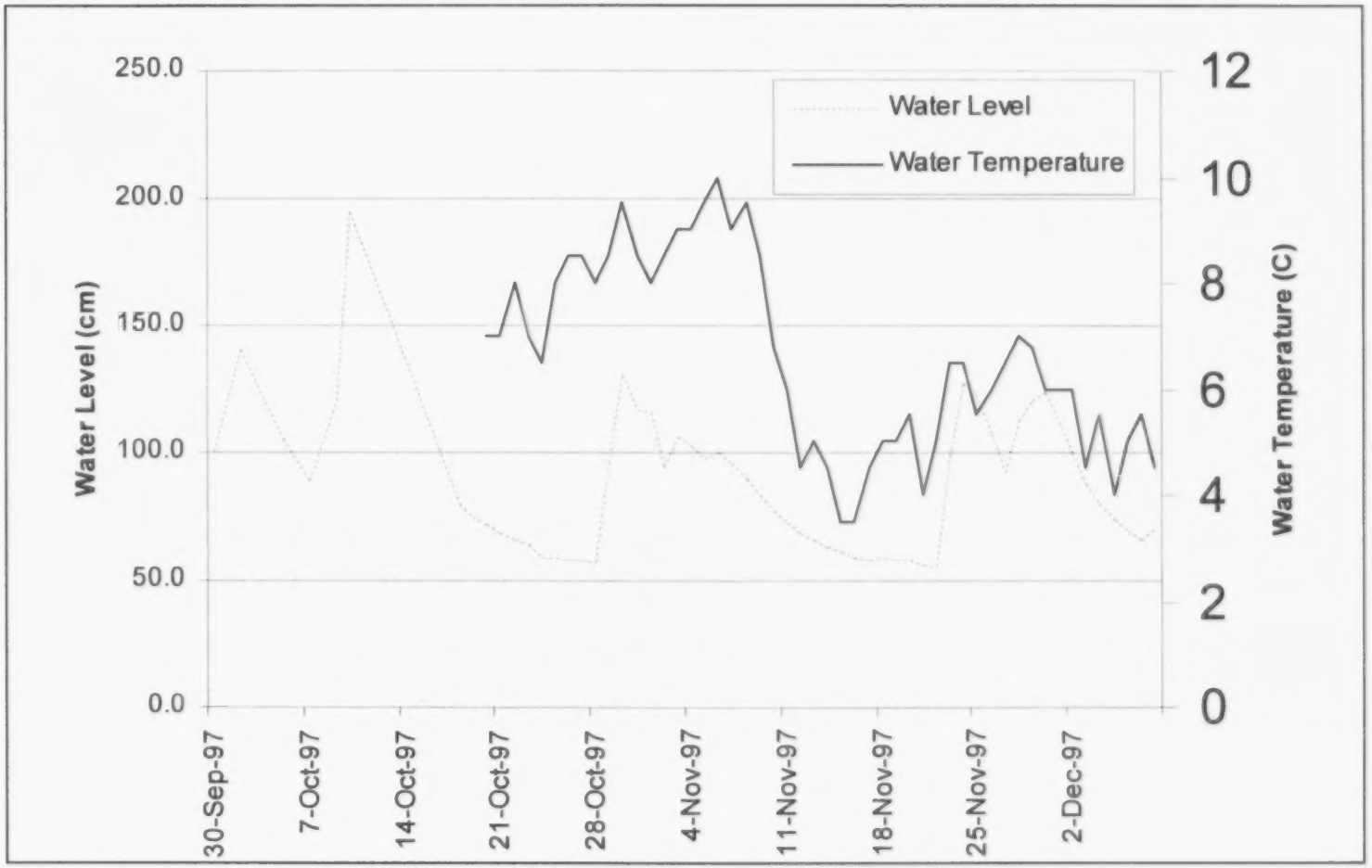

Figure 3.1 Stream conditions during the 1997 adult escapement

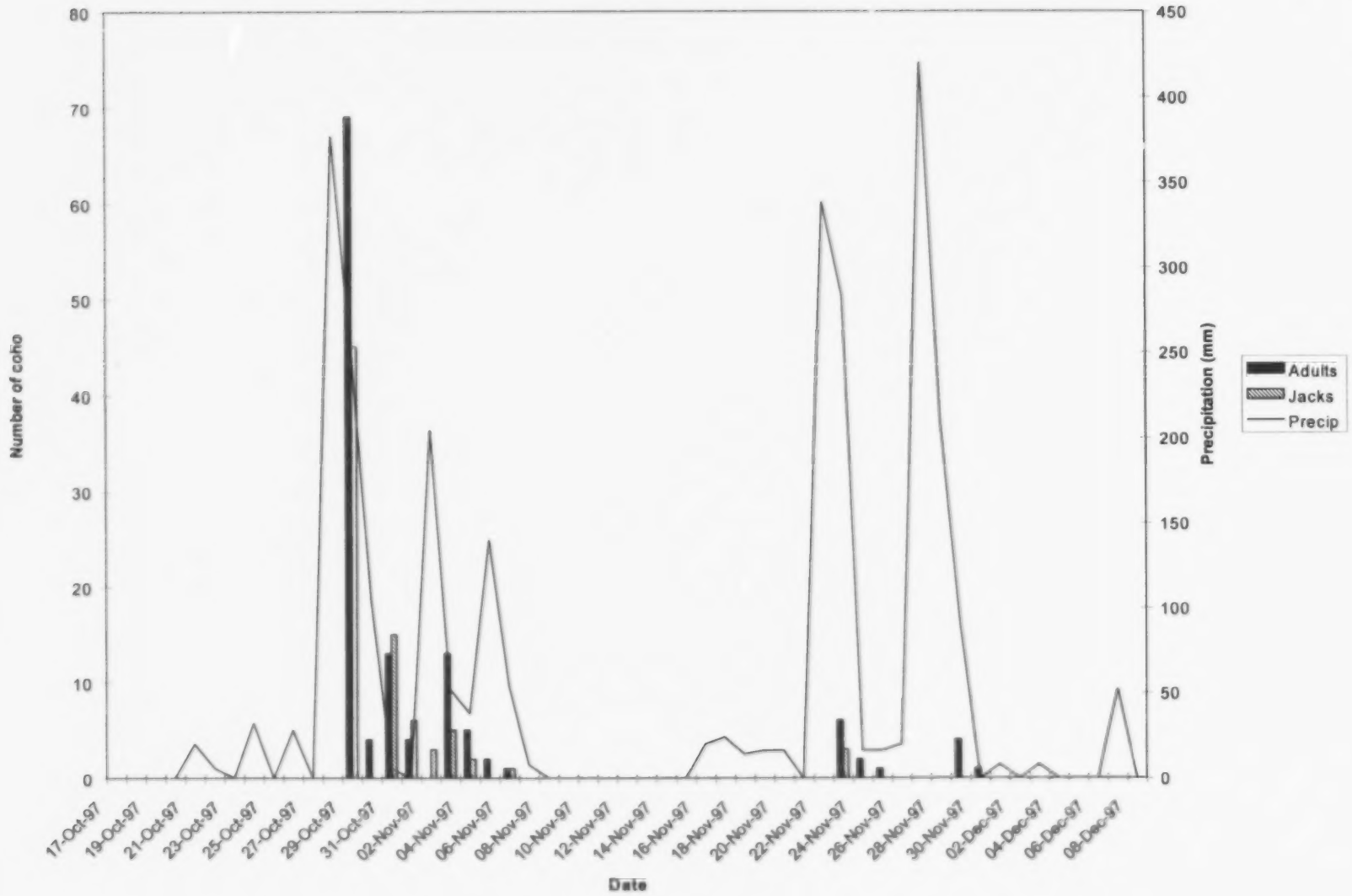

Figure 3.2 Timing of the assessed adult and jack coho escapement and associated precipitation

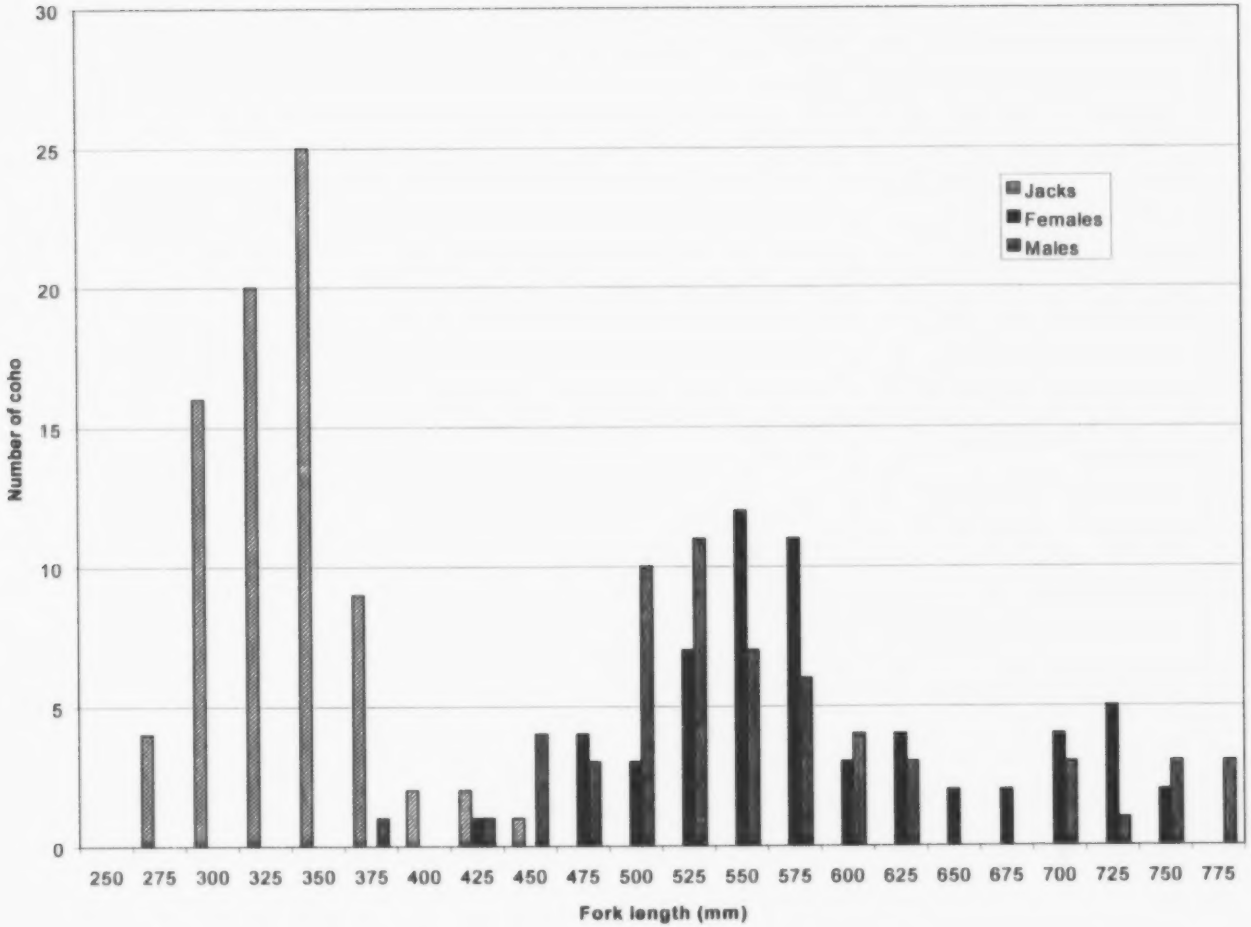

Figure 3.3 Length –frequency distribution of the observed 1997 escapement, by sex